UCSB

HYPERLOOP

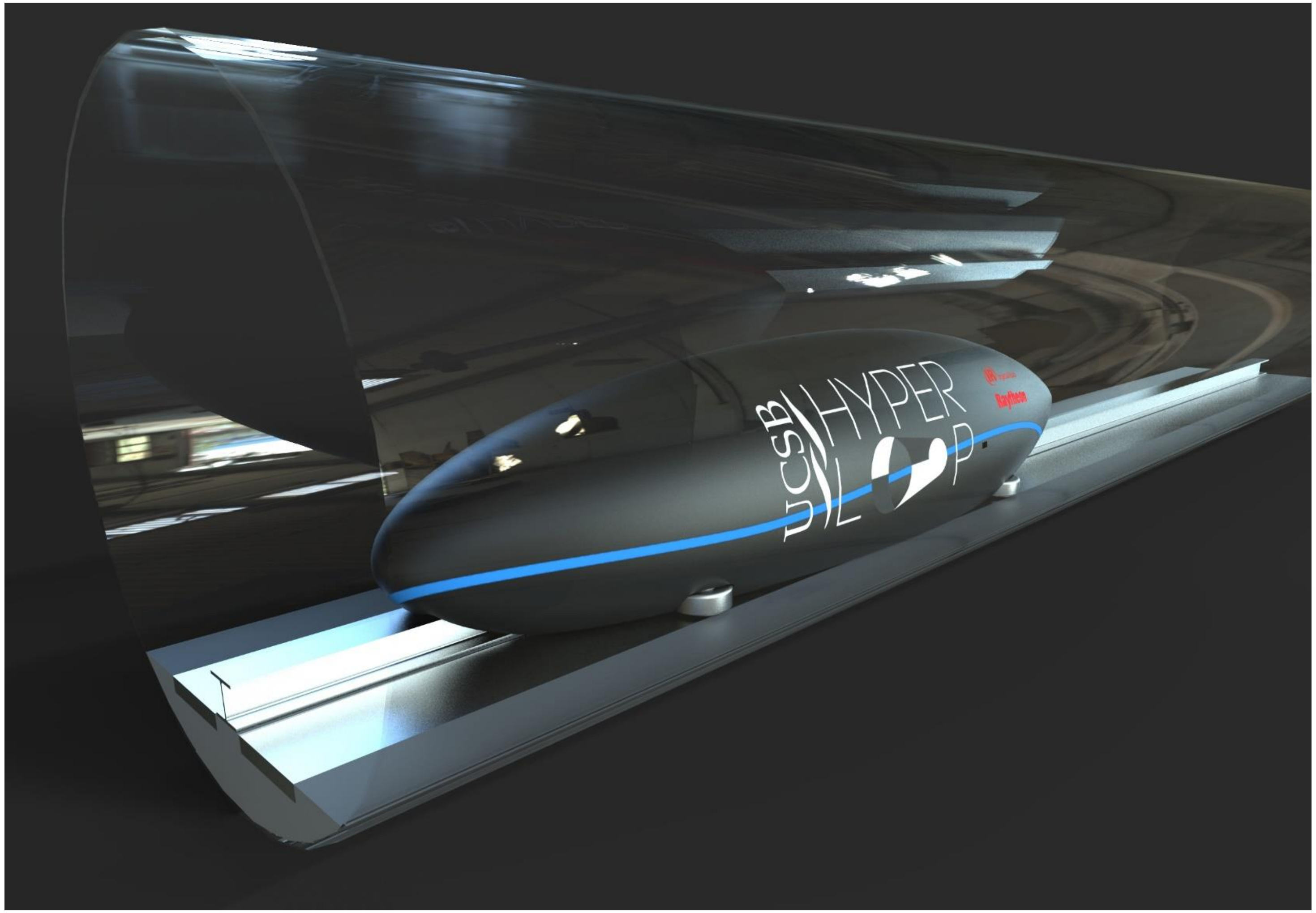
Follow along at:
ucsbhyperloop.com/texas

TEAM

INTRODUCTION

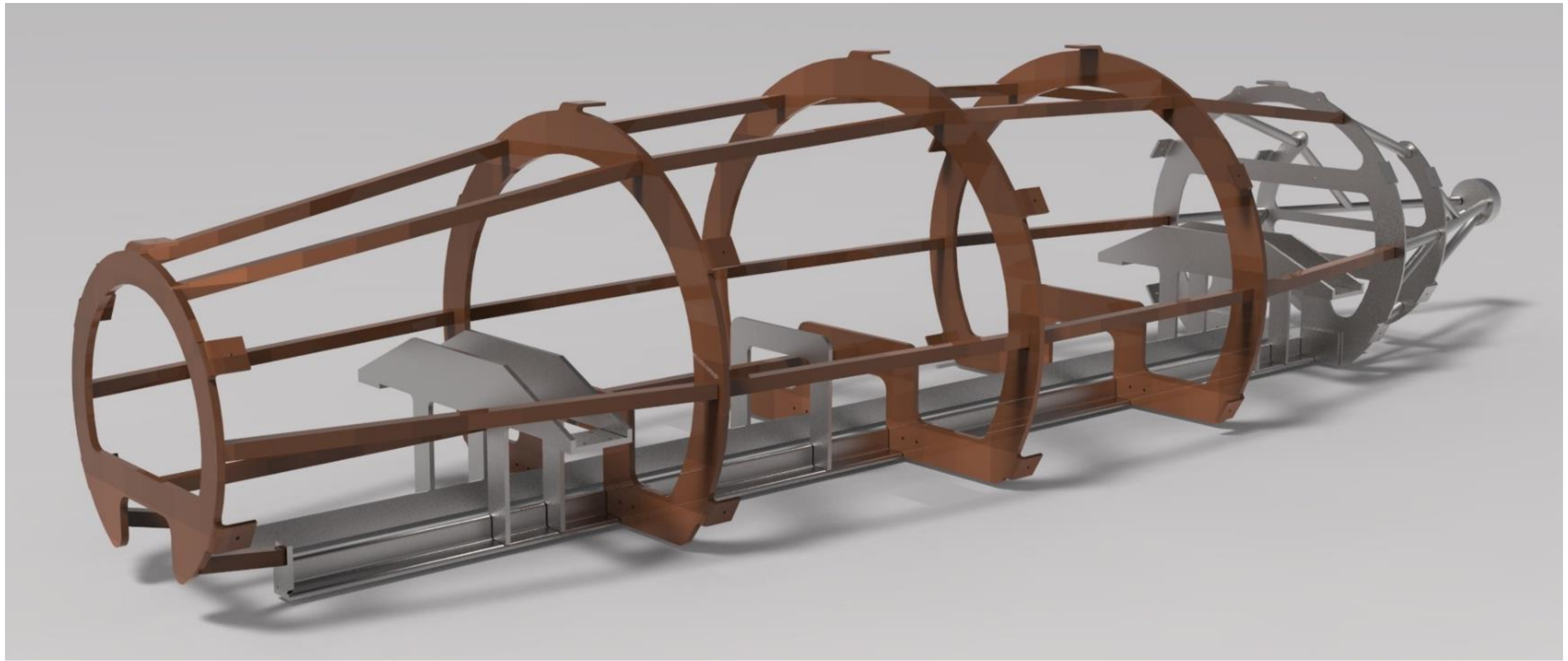
- Follow along at **ucsbhyperloop.com/texas**
- 21 senior engineering undergraduates working to build and test a pod at Competition Weekend
- Emphasizing cost-effectiveness, scalability, and feasibility
- Estimated cost to complete design: $40,000
  - Funding/resources already raised:
    - $5,000 from Ingersoll Rand
    - $5,000 from Raytheon
    - $5,000 from private donors
    - Electronics donated by NXP Semiconductors
  - **~$25,000 to be raised**

POD OVERVIEW



FRAME

- 13’7” (length) x 3’4” (width) x 2’7” (height)
- Divided into front, base, and rear frame
  - Lightweight, wooden front frame reinforces shell
  - Aluminum base frame supports all major subsystems
  - Steel tube rear frame interfaces with SpaceX pusher

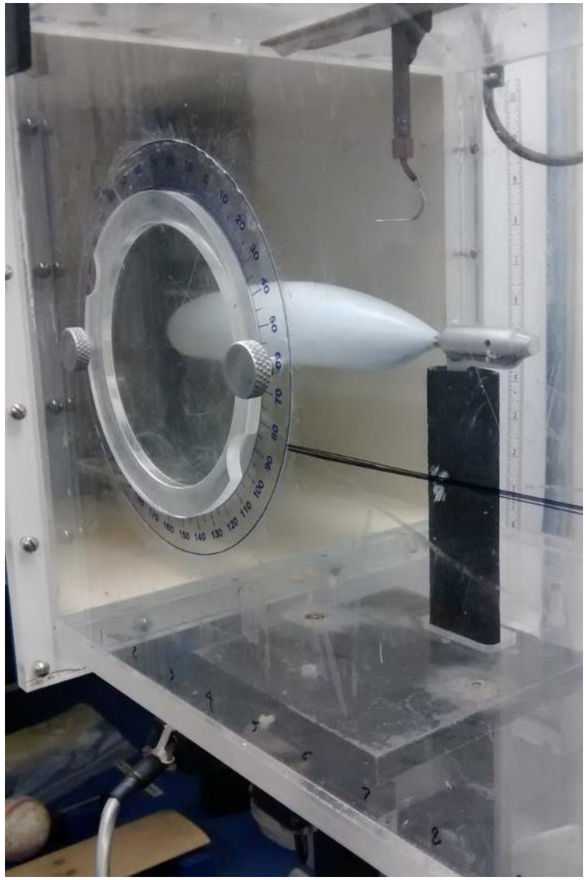


SHELL

- Tapered bullet shape
- E-Glass reinforced polyester
  - Quasi-isotropic material dissipates force evenly in all directions
- Withstands tube pressure breach with a factor of safety of 4000

WIND TUNNEL TESTING

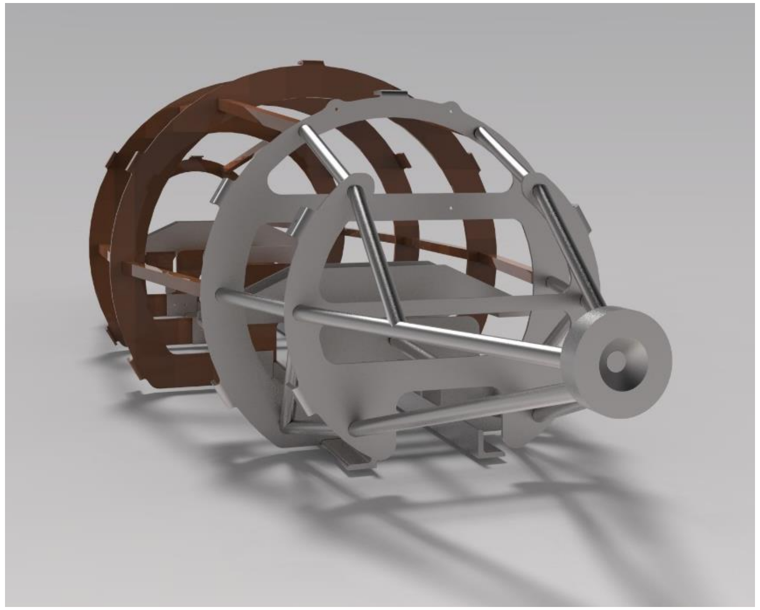
- 3-D printed ABS plastic pod model
- Reynolds number in evacuated tube is 8.5×10^3
- Estimated drag coefficient = 1.5 lbs
  - Drag force = 6.6 N

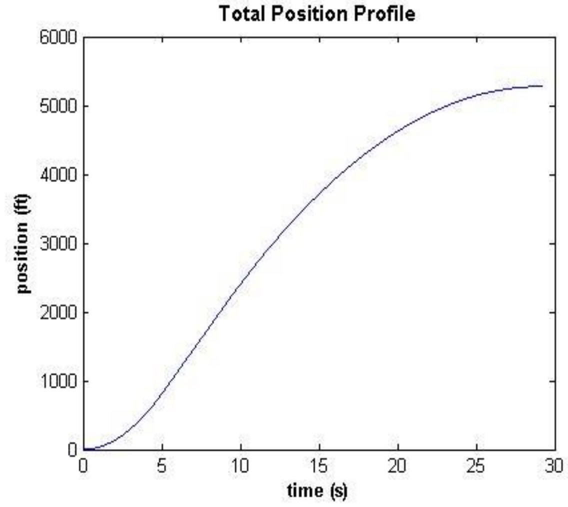


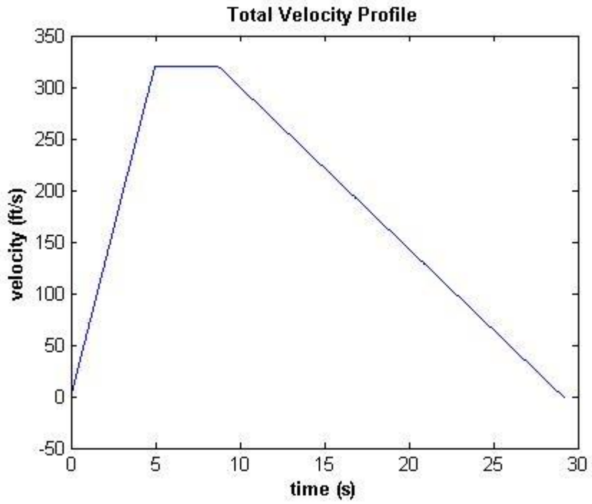
Pod model mounted in wind tunnel

TRAJECTORY

- Top speed of 218 mph (320 fps)
- Total run time of 29.16 s
  - Acceleration – 4.98 s
  - Coasting – 3.75 s
  - Braking – 20.43 s

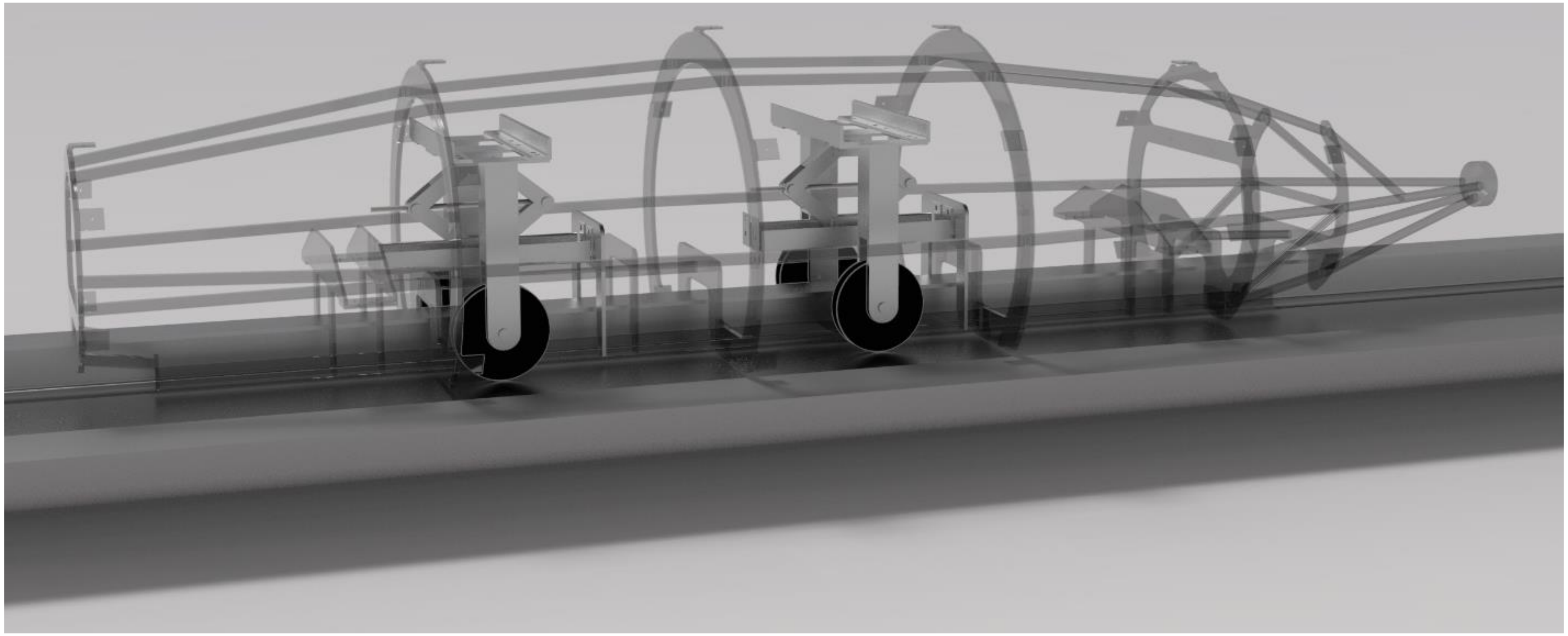






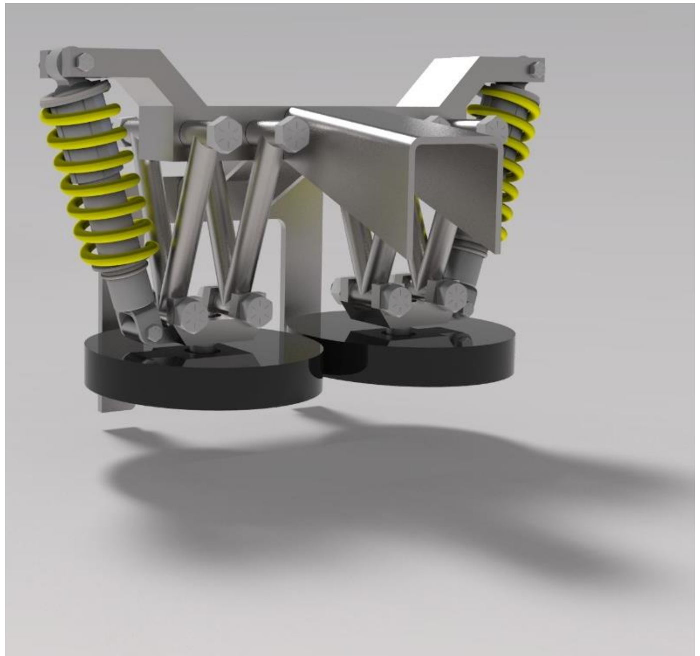
SERVICE WHEELS

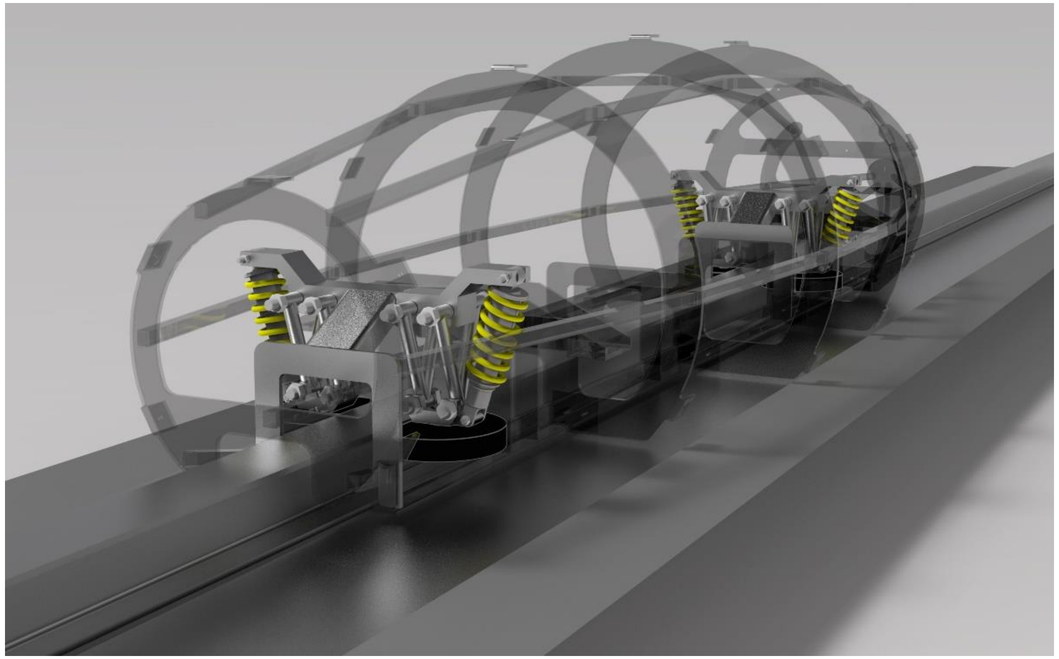
- Powered service wheels for transport and potential pod recovery
- Wheels extend 1/8" below hover engines
- Motorized rear-left support wheel



I-BEAM STABILIZATION

- Benchmarked from roller coaster design and car/motorcycle suspension systems
- Spring-damper resists movement from the parallel linkage
  - Handles lateral forces

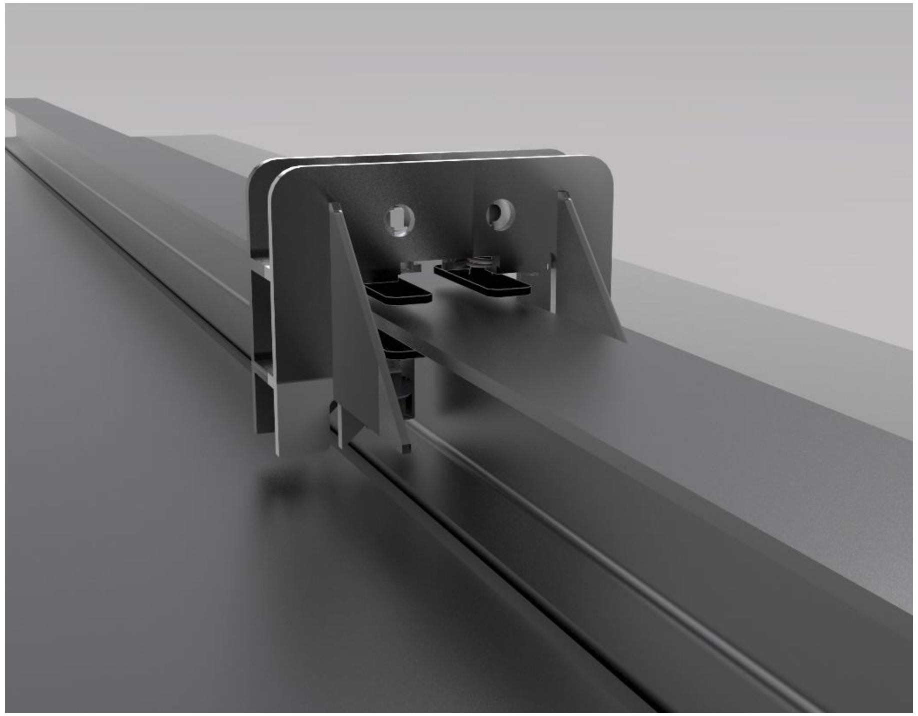


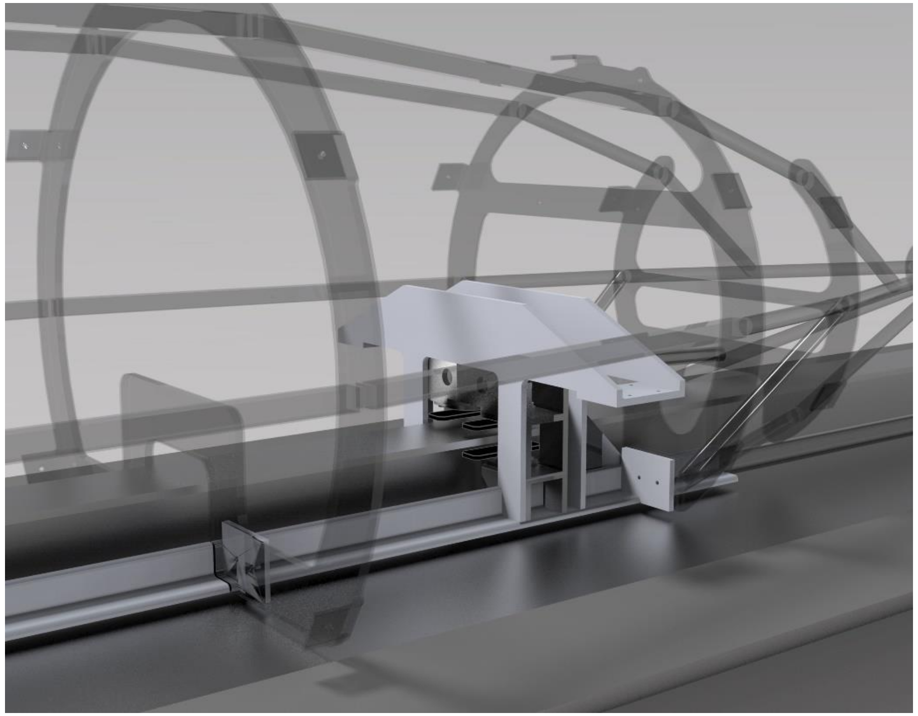


UC SANTA BARBARA engineering

BRAKING

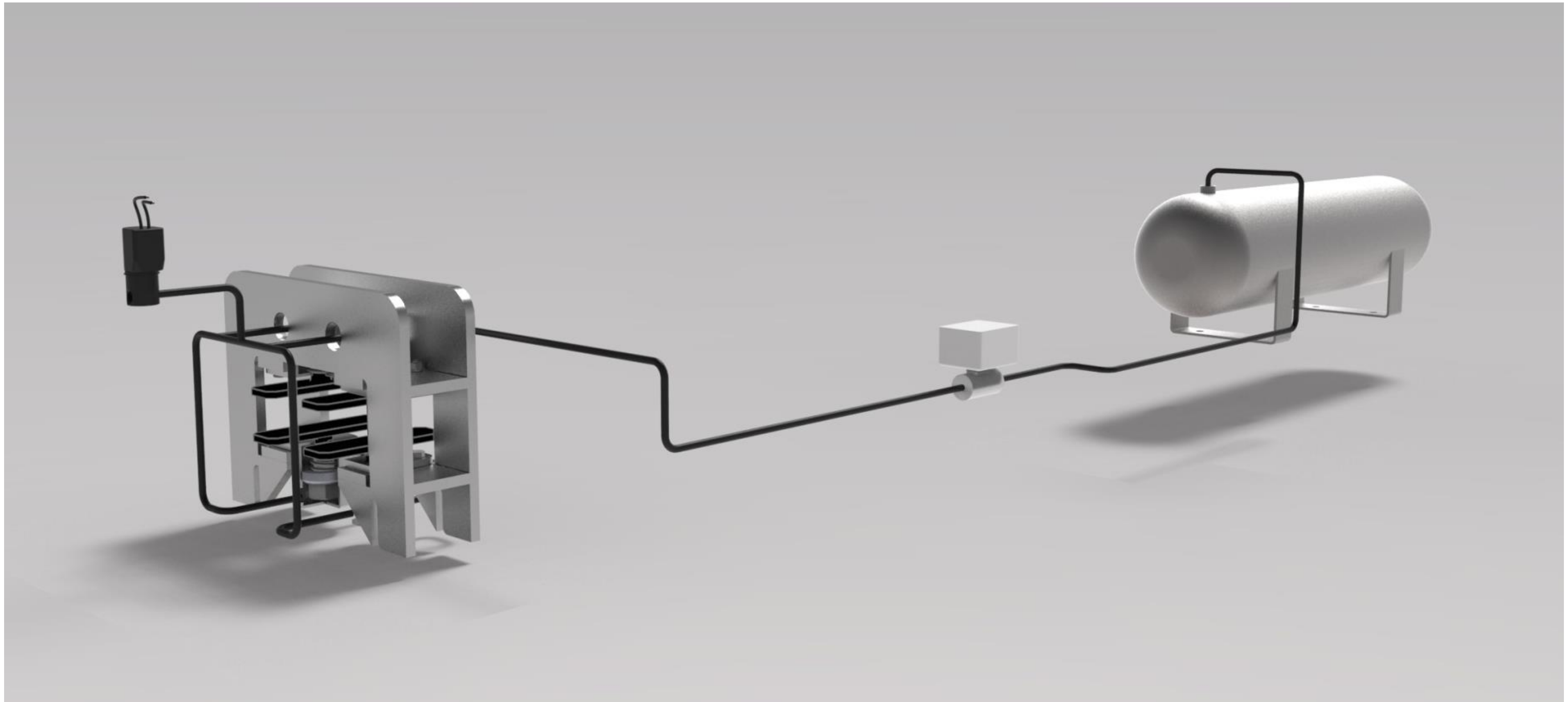
- Pneumatic braking assembly with four actuated brake pads
  - Brake pads clamp onto the I-beam
  - Located at rear of pod





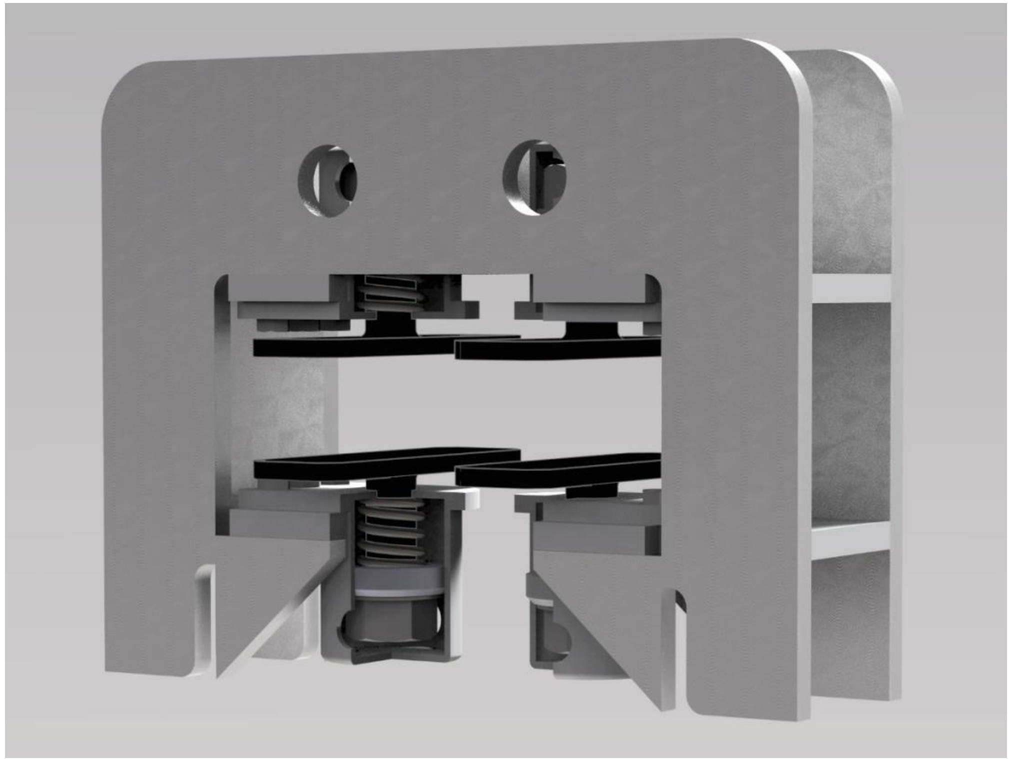
BRAKING

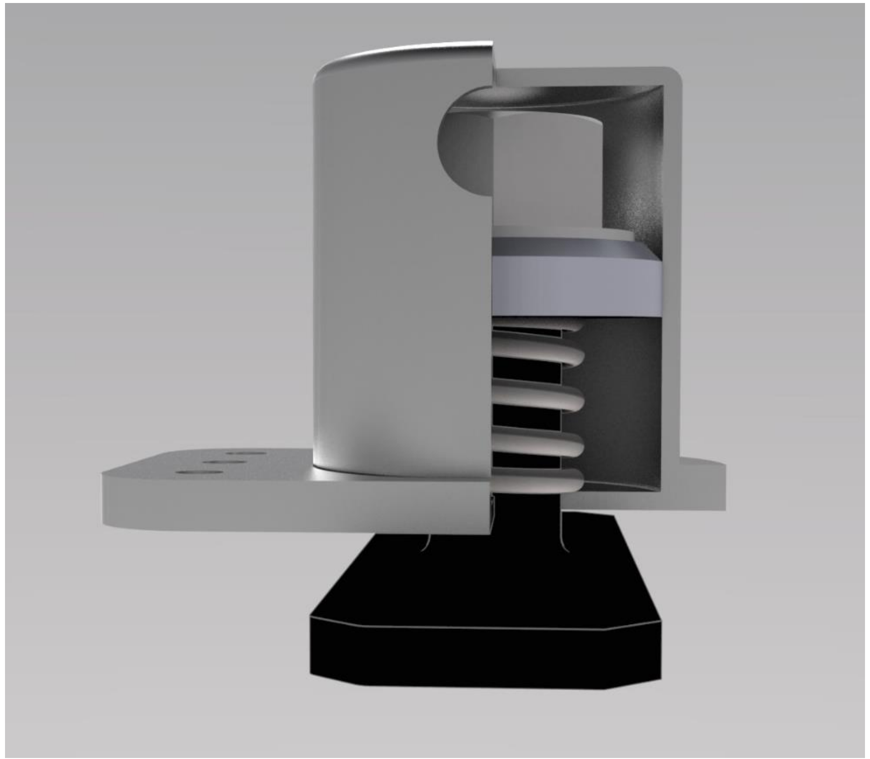
- Pressurized air tank provides pneumatic brake force



BRAKING

- Braking automatically activated by solenoid valves if power fails
- Ball valve manually disengages the brakes





POD WEIGHT

Subsystem	Weight
Frame	66 lbs
Shell	83 lbs
Service propulsion wheels	96 lbs
I-Beam Stabilization	60 lbs
Braking	27 lbs
Maglev Engines	60 lbs
Battery and electronics	63 lbs
Total Weight	**455 lbs**

MAGLEV LEVITATION

- System utilizes four Arx Pax Magnetic Field Architecture (MFA) hover engines
- Ground clearance
  - 0.20” (5mm)
- Four engine payload
  - 550 lbs

MAGLEV LEVITATION

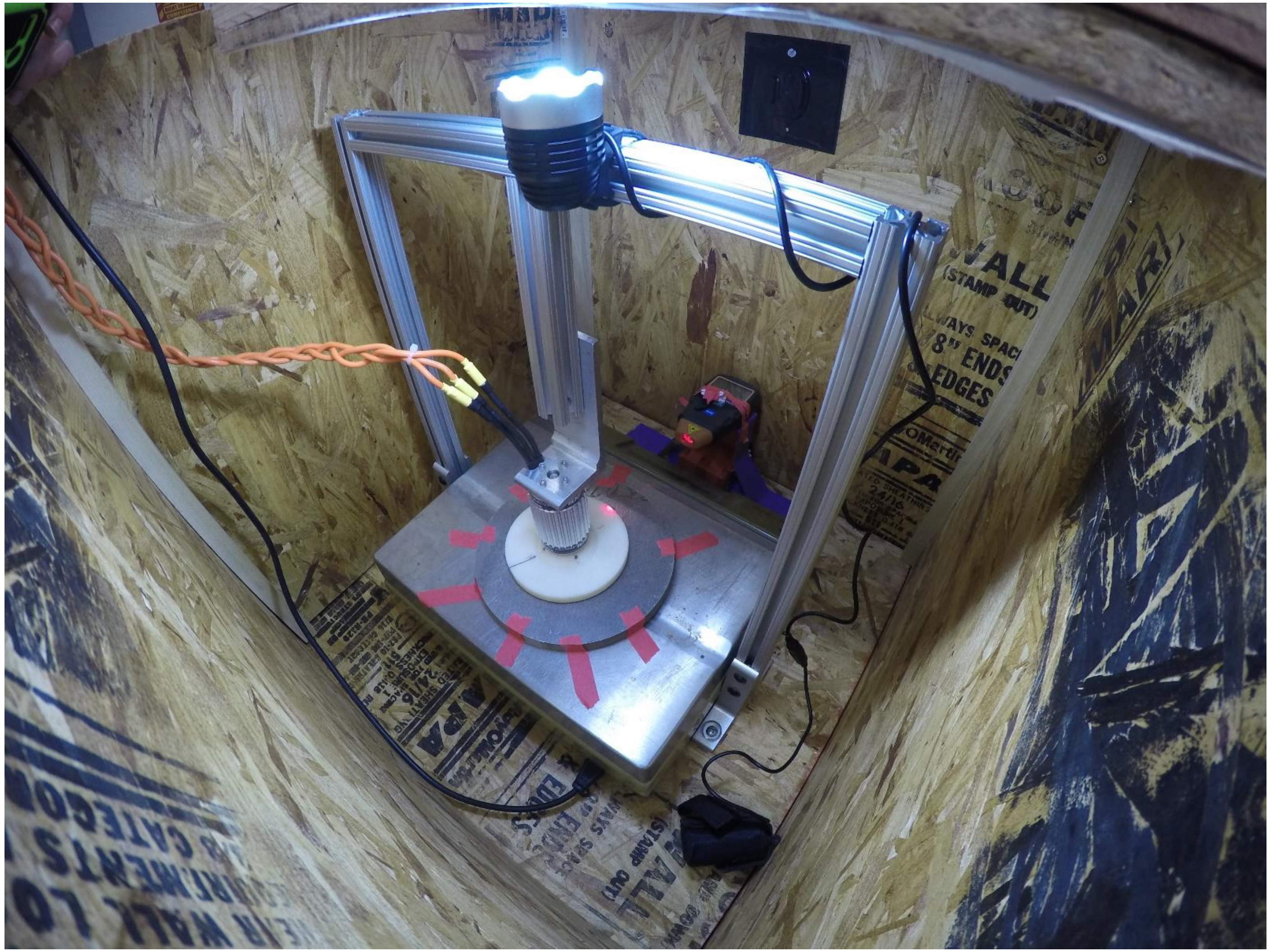
- Best chance of success for competition while still adhering to the future scalability of the Hyperloop
  - Levitation + Propulsion + Braking + Control
  - Operate at high speeds and in low-pressure environments

Arx Pax HE3.0 Hover Engine

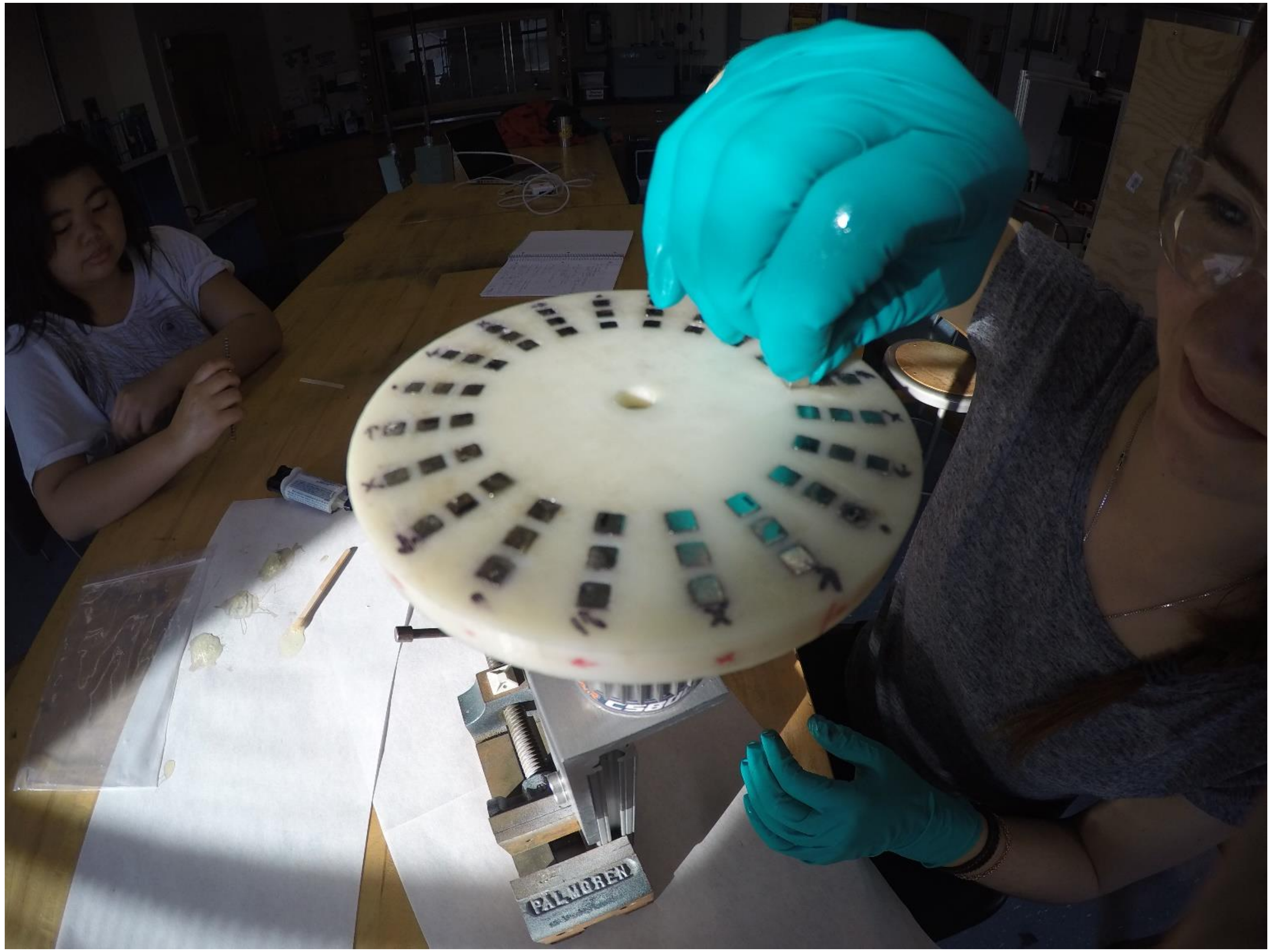
UC SANTA BARBARA engineering

UC SANTA BARBARA engineering

MAGLEV PROTOTYPING



MAGLEV PROTOTYPING

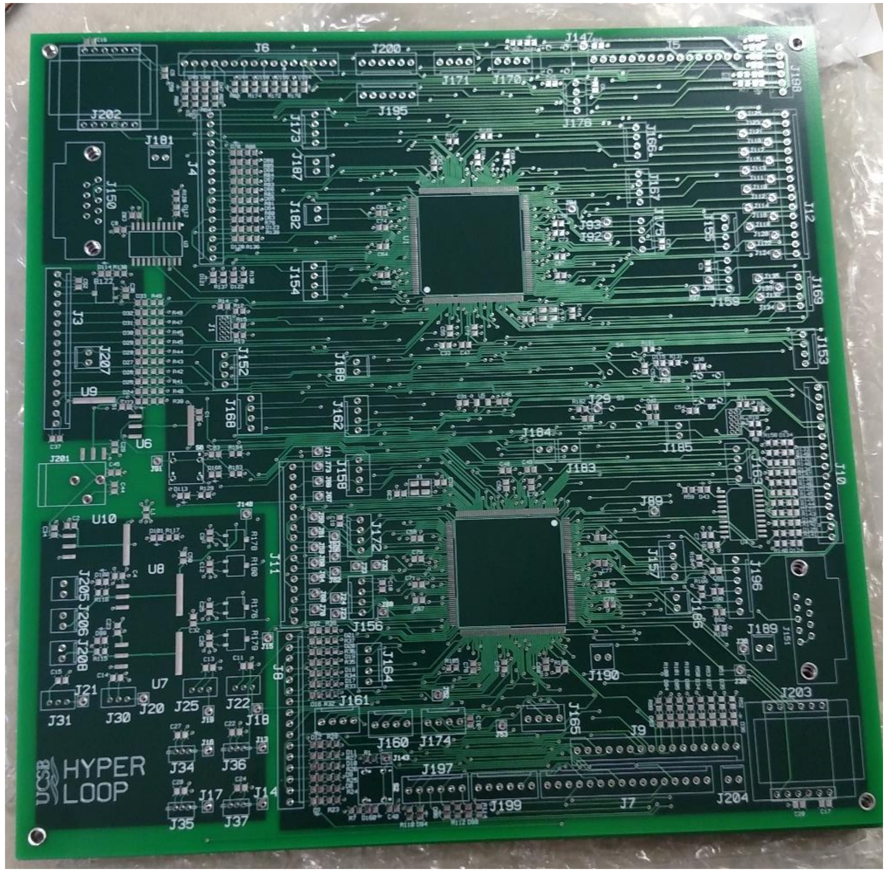


UC SANTA BARBARA
engineering

PRINTED CIRCUIT BOARD

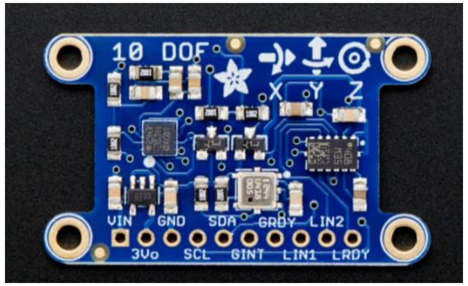
- 8.1” x 8.1” printed circuit board
  - (2) LPC NXP4088 microcontrollers
  - Actuate maglev engines, braking, and service wheels
  - Interface with sensors
  - Communicate telemetry at 1 Hz
    - Interfaces with SpaceX Network Access Panel
  - Execute pod-stop command
  - Manage control systems

- Already fabricated and awaiting assembly



SENSORS

- **Consolidated Board**: *Adafruit 10-DOF IMU Breakout (2)*
  - Positioned at front and back of the pod
  - Combines four sensors:
    - Accelerometer
    - Gyroscope
    - Barometer
    - Thermometer

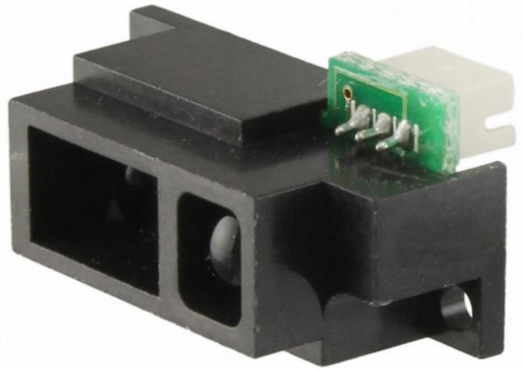


- **Photoelectric sensor**: *Omron E3FB-DP13 2M (2)*
  - Telemetry and navigation
  - Positioned at top of pod
  - Detects reflective strips on the top half of the tube

SENSORS

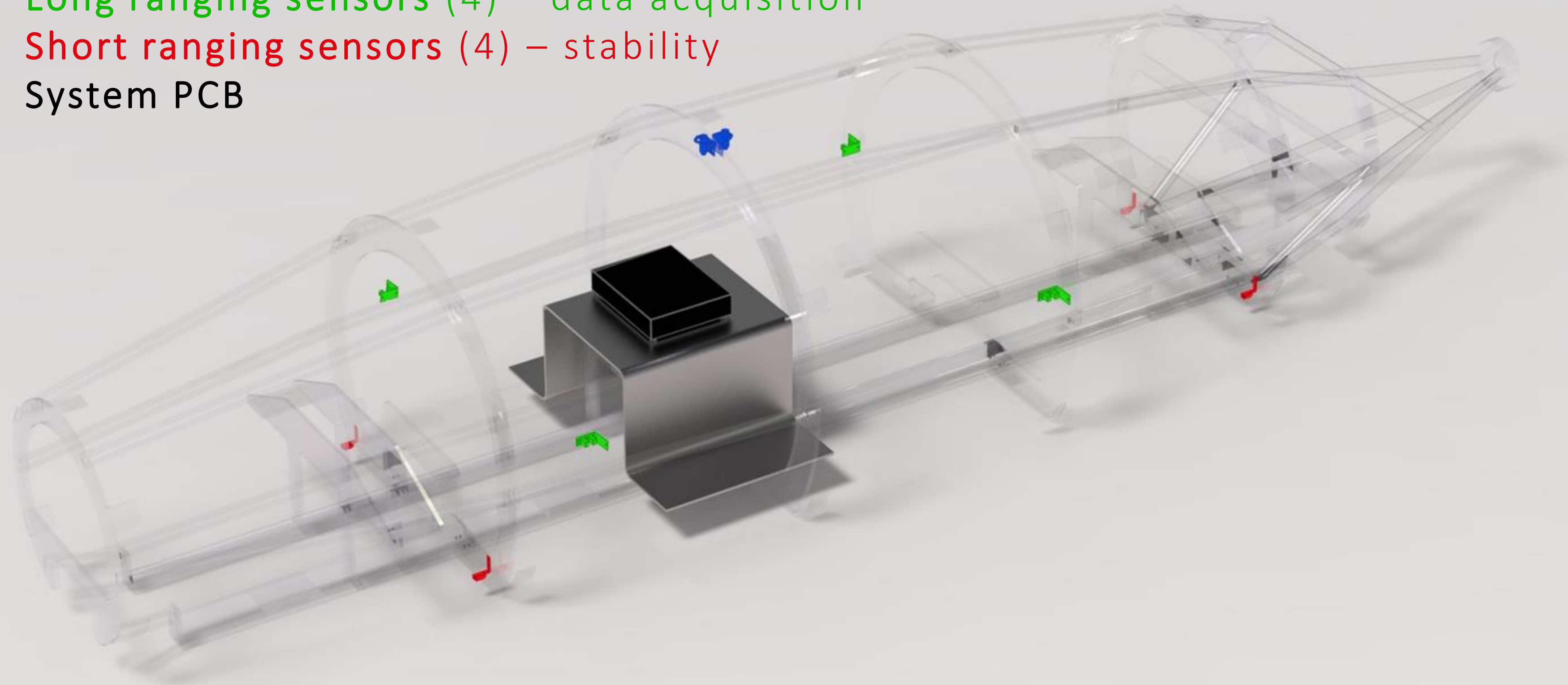
- **Short range**: *Sharp GP2Y0A51SK0F (4)*
  - Telemetry and stability system
  - Positioned at four bottom corners of pod
  - Determines height relative to the bottom of the tube

- **Long range**: *Sharp GP2Y0A02YK (4)*
  - Telemetry
  - Positioned at pod's left and right sides
  - Gives position relative to sides of the tube



SENSOR LOCATIONS

- Photoelectric sensors (2) – navigation
- Long ranging sensors (4) – data acquisition
- Short ranging sensors (4) – stability
- System PCB



UC SANTA BARBARA engineering

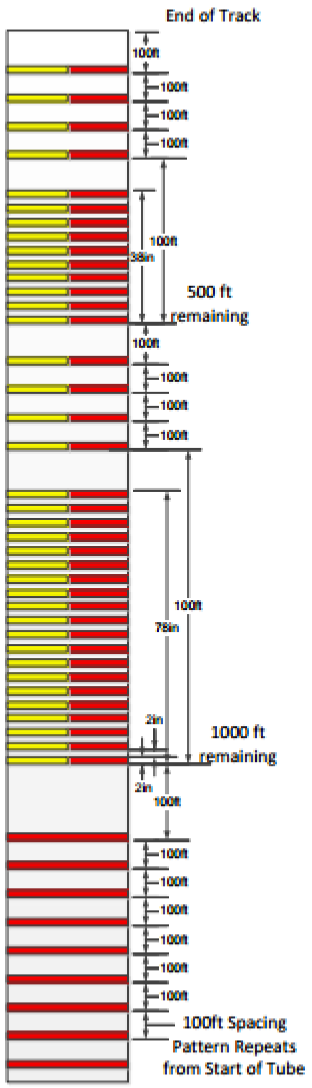
PROTOTYPING

- Currently prototyping sensors on LPC NXP4088 Developer’s Kit
- Testing cabling constraints on a full-sized model

Introduction
Frame
Shell
Propulsion
I-Beam Stabilization
Braking
Weight
Levitation
Electronics
Controls
Power
Scalability
Production
Conclusion

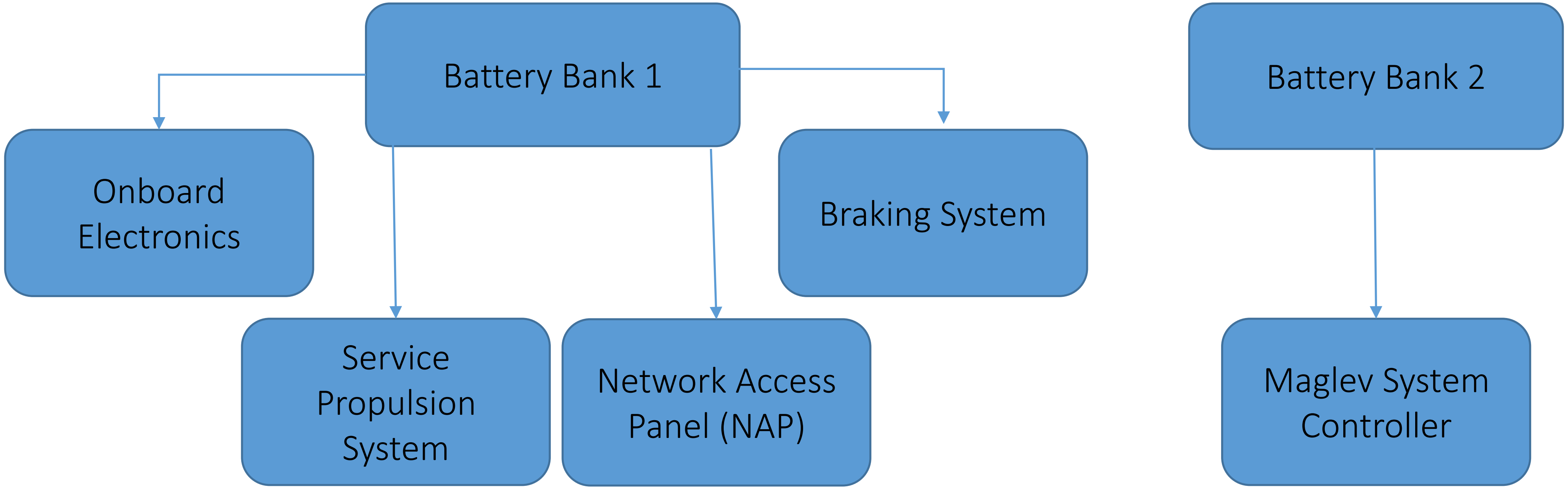
CONTROL SYSTEMS

- Navigation
  - Double integrate accelerometer
  - Recalibrate with diffuse-reflective photoelectric sensor
- Stability
  - 2 gyroscopes at front and back of pod
  - 4 ranging sensors at bottom corners of pod
  - Correct each engine's levitation to maintain stability and correct disturbances
- Braking
  - Microcontroller activates/disengages brake system solenoid valve to apply/release brakes
  - Automatically applied if connection lost for >5 secs

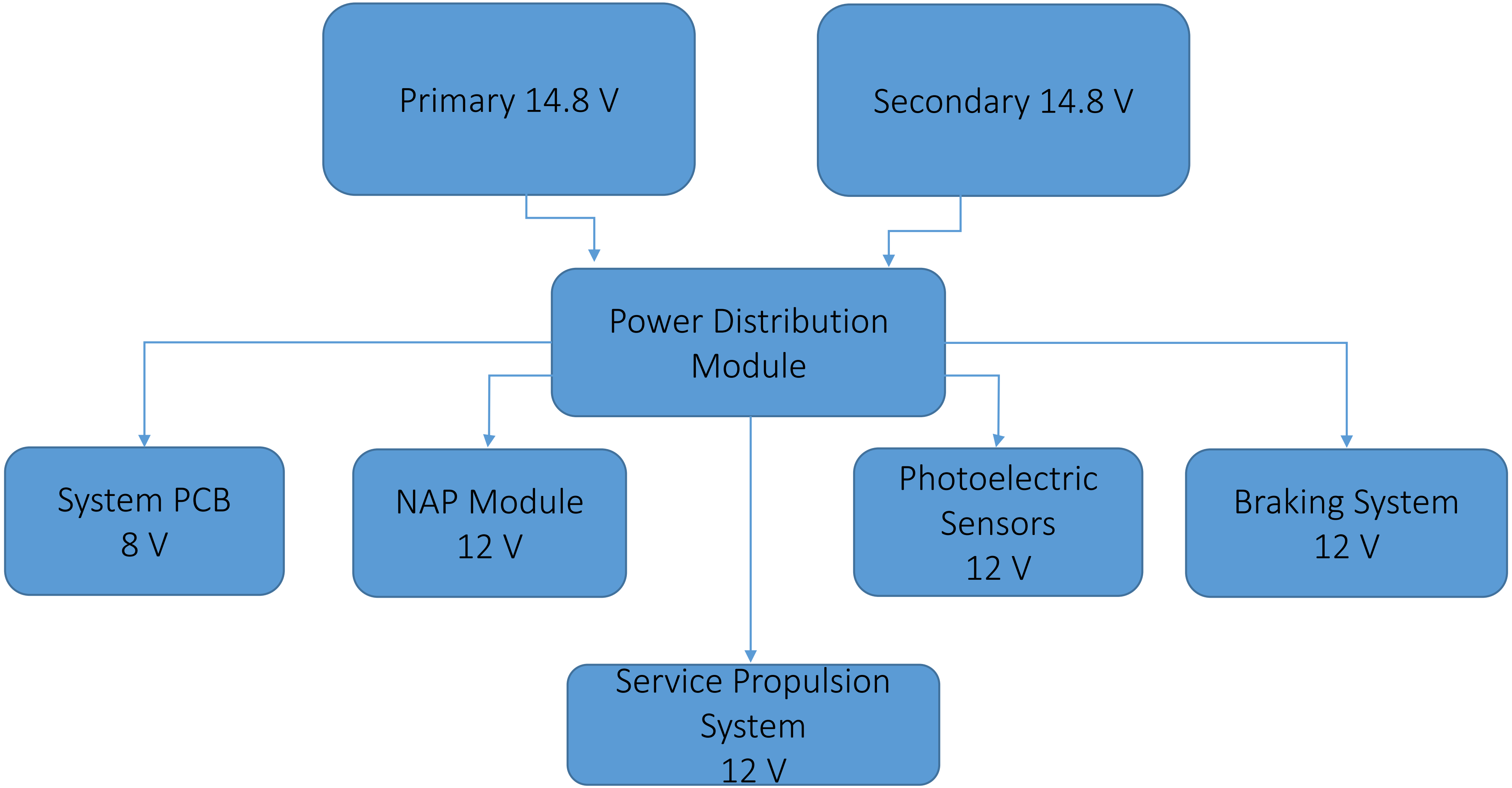


POWER SYSTEM

- **Battery Bank 1**
  - Onboard electronics, NAP, braking, service propulsion
- **Battery Bank 2**
  - Magnetic levitation system

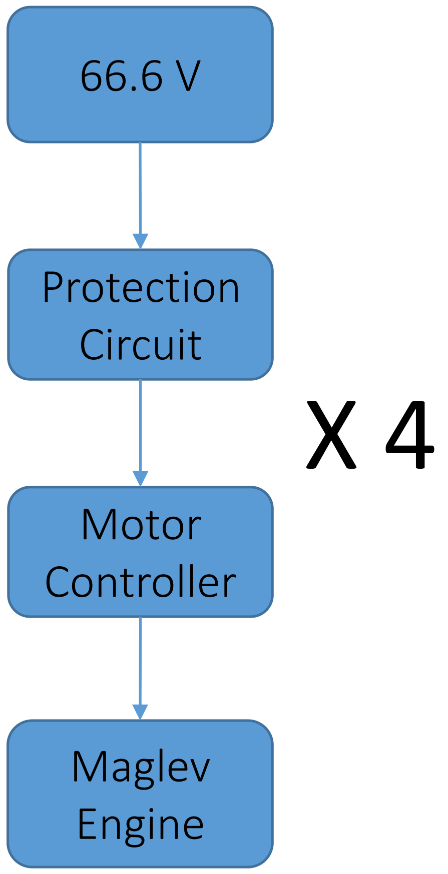


BATTERY BANK 1



BATTERY BANK 2

- Independent power supply for each engine
  - 20Ahr total capacity for 26.2 min of levitation
- Protection circuit to prevent battery over-discharge
- Motor controller communicates with System PCB



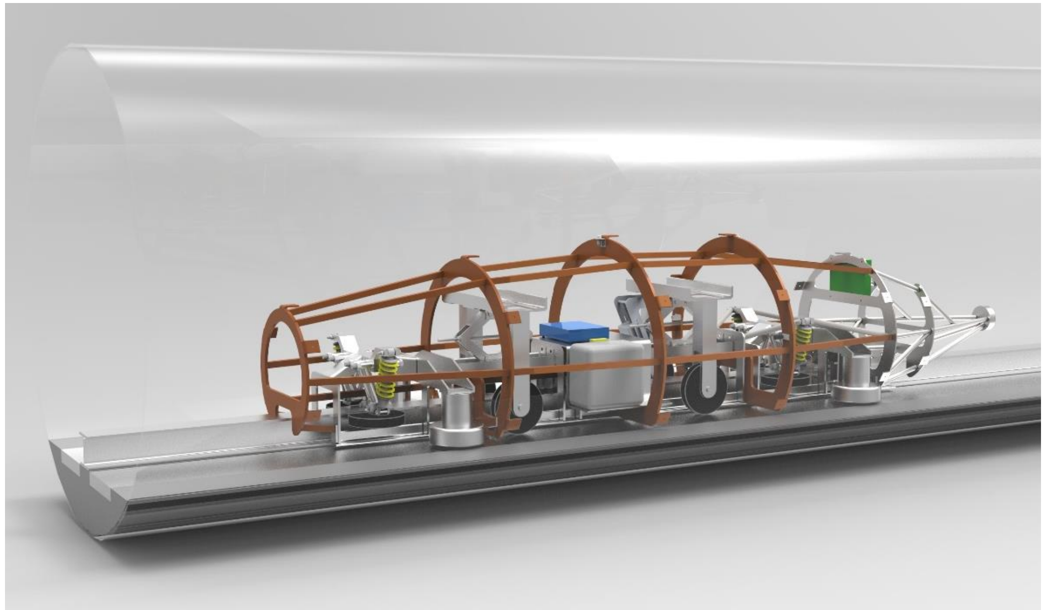
BATTERY SELECTION

- Lithium polymer (LiPo)
  - Battery of choice for quadcopter/drone applications
    - Optimal capacity/weight ratio
    - High discharge rating
    - Easily obtainable off-shelf packs
  - Fire safety
    - Fireproof bags encase each battery bank
    - Stainless steel LiPo charge box to prevent battery puncture in the event of a crash

UC SANTA BARBARA engineering

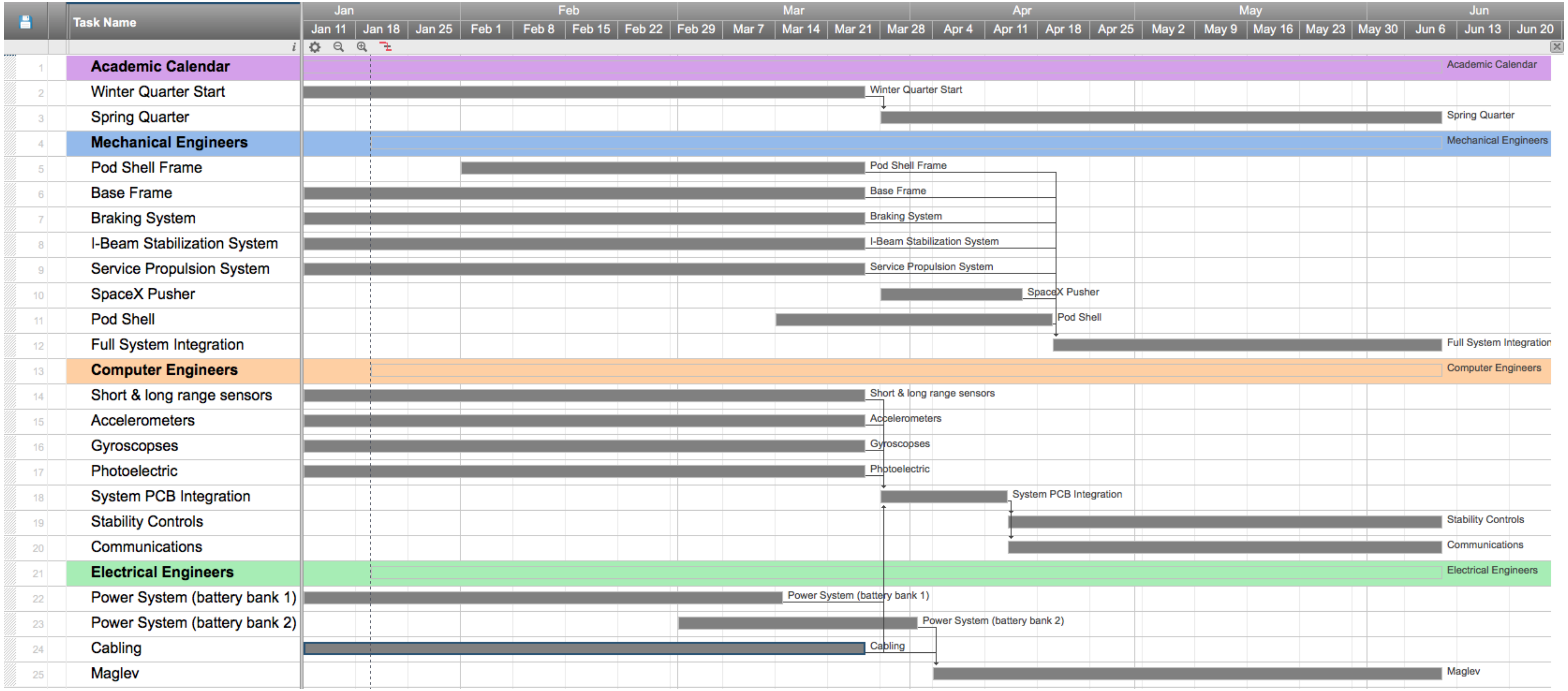
SCALABILITY

- 1/5 of pod weight (87 lbs) relates to the I-Beam
  - I-Beam stability assembly (60 lbs)
  - Pneumatic brakes (27 lbs)
- Maglev engines vs air bearings
  - Tilting the maglev engines can provide braking and propulsion
  - Highly scalable controls software architecture



UC SANTA BARBARA engineering

PRODUCTION SCHEDULE



CONCLUSION

- Work began in October 2015
  - With school schedules—effectively 12 weeks of work

- Accomplishments
  - **Raised $15,000—need $25,000 to reach goal of $40,000**
  - Printed Circuit Board is in assembly
    - Prototyping sensors with NXP Developer's Kit
  - 3D printed model
    - Used for extensive wind tunnel testing
  - Magnetic levitation testing & prototyping
  - Styrofoam and PVC pipe model of frame completed
    - Beginning to work with cabling
  - Established a finance/marketing team

CONCLUSION

- Thank you to our mentors and our sponsors.
- Please find us at Booth 64 or contact us:
  - ucsbhyperloop.com
  - ucsbhyperloop@gmail.com
  - @UCSBHyperloop